Remarks

Entry of the amendments presented herewith, reconsideration of the application and allowance of all claims are respectfully requested. Claims 1-41 remain pending.

In accordance with 37 C.F.R. §1.121(c)(1)(ii), a marked-up version of the amended claims is provided on one or more pages separate from the amendment. These pages are appended at the end of the Response.

Applicants have herein amended independent claims 1, 19, 23, 34 & 37 to more particularly point out and distinctly claim certain features of applicants' invention which directly relate to the problem addressed herein. These amendments to the claims constitute a *bona fide* attempt by the applicants to advance prosecution of this application and obtain allowance of certain claims and are in no way meant to acquiesce as to the substance of the final rejection. It is believed that the amendments to the claims place all claims in condition for allowance.

The Office Action cites Reininger et al. (U.S. Patent No. 5,426,463) in view of Astle (U.S. Patent No. 5,751,861) as allegedly rendering obvious the independent claims of applicants' invention (i.e., claims 1, 19, 23, 34 and 37). This conclusion and the characterizations of the teachings of Reininger et al. and Astle are respectfully traversed to any extent deemed applicable to the claims presented herewith.

Before discussing the claims at issue, applicants again wish to gratefully acknowledge the indication of allowable subject matter in dependent claims 3-6, 9-29 and 30 if rewritten into independent form including all limitations of the base claim and any intervening claims. These claims have not been rewritten herein, however, since the independent claims from which they depend are believed to recite patentable subject matter for the reasons stated below.

In prior responses to Office Actions, applicants have sought to further characterize the problem or environment which results in applicants' recited adaptive encoding. In an attempt to further prosecution of this application, applicants herein further characterize the adaptive process itself. More particularly, the independent claims are amended to recite that the adapting of the encoding includes adjusting at least one controllable parameter employed in the encoding of the still frame to disable motion estimation and limit motion compensation to minimize after decoding thereof, visually perceptible pulsation artifacts between still frames of a sequence of still frames. Thus, applicants reduce, or eliminate, pulsation artifacts from a sequence of still frames by disabling the motion estimation and limiting motion compensation when a still frame of the sequence is identified. Disabling motion estimation and limiting motion compensation encourages the skipping of the macroblocks in the still frame being encoded. By definition, a skipped macroblock is duplicated, without change, from a prior, reference picture.

In the present application, after determining that a frame is contained within a sequence of still frames, motion estimation is disabled to ensure that the motion estimation vector is zero, thereby allowing a reference frame versus current frame comparison to be performed on the same coordinates or placement within the frames. For example, if a current macroblock of a frame is located within a still frame at pixel row index 48 and pixel column index 64, the only comparison allowed will be at the same coordinates in the reference frame.

Further, motion compensation is limited in a still frame by allowing any difference value between the two macroblocks that fall below a predetermined threshold to be nullified or artificially set to zero. This allows macroblocks that would ordinarily fail the criteria for skipping to be skipped, thus reducing or eliminating the possible artifacts that would occur in normal compensated macroblocks due to lossy compression noise.

Neither Reininger, et al. nor Astle, taken separately or together, teach or suggest applicants' above-noted process for artifact reduction when encoding frames with constant content from frame to frame (i.e., still frames contained within a still sequence of frames).

Neither Reininger, et al. nor Astle address the disabling of motion estimation to guarantee zero valued motion vectors, nor does either patent discuss a threshold for artificially nullifying macroblock differences and thus limiting motion compensation for the purpose of allowing more skipped macroblocks within a still frame.

The Office Action acknowledges that Reininger et al. does not appear to disclose the limitation of "minimize after decoding thereof, visually perceptive pulsation artifacts between still frames of a sequence of still frames". In furtherance of this statement, applicants respectfully submit that Reininger et al. do not discuss adaptively encoding a still frame to disable motion estimation and limit motion compensation while encoding the still frame. The Office Action cites the teachings of Astle to address the deficiencies of Reininger et al. Astle teaches low-pass filtering to eliminate block-edge artifacts, thus changing the values of some of the pixels themselves within the current picture. A careful reading of Astle fails to uncover any teaching, suggestion or implication of an adaptive encoding approach wherein motion estimation is disabled and motion compensation is limited when encoding a still frame of a sequence of still frames, let alone such adapting to minimize, after decoding thereof, visually perceptible pulsation artifacts between still frames of the sequence as recited by applicants in the independent claims presented herewith.

For all the above reasons, applicants respectfully submit that the independent claims presented patentably distinguish over the applied art, and request reconsideration and allowance of all claims.

In further support of applicants' position, certain content from applicants' prior response is repeated hereinbelow for the Examiner's ready convenience.

Applicants recite in the independent claims that the "still frame" and "still macroblock" comprise a frame and macroblock with certain content identical and unvarying to content of a preceding frame or a corresponding macroblock in a preceding frame. Thus, the phrase

"sequence of still frames" as defined in the present application and used in the claims, is distinguishable from the interpretation given the phrase in the above-referenced Office Action. Applicants recognize as suggested by the Examiner that each frame in a sequence of frames is just that, a frame itself. However, the phrase "still frame" or "still macroblock" is used in the present application to mean that certain content of the frame does not vary from one frame to the next, i.e., that the content is fixed over a period of time such that a particular frame has little or no pixel difference with the frame preceding it. For example, a motionless test pattern depicted over a period of time so as to be represented by multiple frames would mean that there is a sequence of still frames such that any one frame contains content that is identical and unvarying to content of a preceding frame.

By way of further explanation, one specific definition of a "still frame" is an input frame to an encoder whose pixel data does not vary by either value or position with respect to the temporally previous frame input to the encoder. That is, frame i+1 contains identical pixel data to frame i for the entire frame. An example of such a still frame would be that the exact same picture is being fed into an encoder over a period of time.

As a further example, a partially still frame may comprise an object or objects within an input frame to an encoder whose pixel data does not vary by either value or position with respect to the same object or objects contained within a temporally previous frame input to the encoder. That is, frame i+1 contains identical pixel data for an object or objects contained within the frame to the identical object or objects contained within frame i. An example of a partially still frame would be a series of frames whose background is constant, say a tree or house, which does not move or change position, although an object or objects in the foreground may, such as a car driving by the house.

The meaning of "still frame" is significant to the present invention. The problem addressed by the present invention is the existence of "pulsation artifacts" which may occur after decoding of a series of encoded still frames. As used in the present application, "pulsation

artifacts" is the result of encoding and decoding processes on successive frames having certain identical and unvarying content (i.e., still frames). Due to slight variations in the details in the encoded frames, visually apparent fluctuations in the decoded and displayed images may occur. These differences may give the impression of motion, and are known in the art as pulsation artifacts. Thus, while the initially received sequence of video frames may comprise a series of identical "still frames" in raw data format, after the still frames have undergone lossy compression and decompression (i.e., encoding and decoding) there may visually appear artifacts in the ultimately displayed image resulting from the lossy compression and decompression of the images. The present invention is directed to minimizing these artifacts with display of the ultimate image. Again, because of the compression techniques used, a video image that contains certain content identical and unvarying to certain content of the previous and/or next images may not be displayed identically after decompression of that image. Variations in, for example, luminance and/or chrominance data of the decoded images may falsely give the impression of movement of the identical content from one image to the next. This is also referred to in the application as "apparent" movement of the still pictures.

In accordance with applicants' invention, a determination is first made that a still frame in a sequence of still frames in a series of video frames has been received at the encoder. The independent claims further recite that a "still frame" comprises a frame with certain content identical and unvarying to certain content of a preceding frame. Thus, a sequence of still frames comprises a special case within a sequence of frames wherein there is no motion of certain content from one frame to the next. Applicants then adapt encoding of that still frame in order to minimize subsequently occurring visually perceptible pulsation artifacts between that still frame and an adjacent still frame after the frames have undergone encoding and decoding. The problem addressed by the present invention exists when a series of identical or nearly identical still frames are encoded and then decoded for display. When such frames are displayed, visually perceptible "pulsation artifacts" may occur. The present invention thus seeks to minimize these pulsation artifacts which would otherwise occur after decoding of an encoded still frame by adjusting the at least one controllable parameter employed in the encoding of that still frame.

In comparison, Reininger et al. describe a multi-pass encode system which uses the number of bits produced from encoding a macroblock as feedback to change the quantizer used on the same macroblock in the same frame in a next encode pass. If the number of bits produced for a macroblock on a pass is greater than a threshold number, then the quantizer is changed for a next encode pass.

Initially, Applicants note that Reininger et al. do not address or discuss the same problem as that to which the present invention is directed. A careful reading of Reininger et al. fails to uncover any discussion of processing still frames as the term is defined and used in the present application, let alone recognizing the pulsation artifact problem addressed by Applicants, or Applicants claimed solution to the problem. Reininger et al. address the uniformity of image quality by limiting the amount of compressed data produced by the encoding process. Applicants' invention, however, is directed to minimizing visually perceptible pulsation artifacts occurring in a sequence of still frames which are displayed after undergoing encoding and decoding of the identical frames.

As used in the present application, a still frame is any frame in a series of received video frames that has certain identical and unvarying content to certain content in the previous and/or next frame such that the raw data frames contain at least partially visually identical information. Therefore, when the images are displayed, the visual appearance should remain constant from one frame to the next notwithstanding the encode and decode processing of the data which has occurred.

In contrast, Reininger et al. disclose a system for encoding video data which includes calculating the bits produced and encoded (i.e., compressed) for macroblocks within a single frame, and using this information as feedback for further refinements in the encode process. Reininger et al. determine the number of bits produced for macroblocks within a frame, and if the size is too large, then the quantizer is changed for the subsequent encode pass. Essentially,

Reininger et al. disclose a constant bit rate encode process which seeks to maintain picture quality without violating the constant bit rate. To accomplish this, Reininger et al. evaluate the same picture in compressed data format multiple times. (See column 4, lines 3 et al). Applicants respectfully submit that this process of Reininger et al. is substantially different from Applicants' recited processes.

In the Office Action, the Examiner essentially mischaracterizes a still frame as an I-picture. This mischaracterization of the prior art and application thereof to the problem addressed by the present invention is respectfully traversed. Each of the independent claims presented herewith defines "still" as a frame or macroblock that has certain content identical and unvarying to certain content in the preceding frame or macroblock in a series of frames. Thus, the still frame or macroblock has minimal pixel difference from one frame to the next. It is the existence of such still frames which gives rise to the problem addressed by the present invention. Not every frame in a group of frames necessarily comprises a still frame as the phrase is defined in the independent claims presented herewith. Typically, there is content motion (i.e., change) from one frame to the next in a sequence of video frames. If there is content motion from one frame to a subsequent frame, the frames necessarily do not comprise still frames as defined in the present application.

In contrast to applicants' "still frame", an "I-picture" refers to a type of encoding performed by an encoding process on a frame. As is well known in the art, a frame can be encoded as an I, P or B frame. Thus, an I-picture or reference picture refers to a type of picture resulting from the encoding process. In the present application, the "still frame" comprises a frame characterization which is determined prior to the encoding process. As noted above, applicants' "still frame" refers to there being certain content identical and unvarying to certain content in the preceding frame. Once a still frame is identified, then in applicants' process the encoding is adapted to minimize after decoding of the encoded stream, visually perceptible pulsation artifacts between still frames of a sequence of still frames. Applicants' use of "still

frame" has nothing to do with the type of picture encoding employed for the frame. A still frame could be encoded as an I, P or B picture.

To summarize, Applicants are addressing a problem unique from that of Reininger et al. Specifically, Applicants seek to minimize visually perceptible pulsation artifacts which occur in a displayed video stream after the stream has undergone encoding and decoding processes, and in particular, which occur where the stream contains a series of still frames, i.e., frames with at least partial content which is identical and unvarying from frame to frame. Reininger et al. does not address or even discuss the existence of a series of still frames within a sequence of video frames, nor does the patent address the problem of visually perceptible pulsation artifacts occurring upon displaying a sequence of still frames which have undergone encode and decode processes. Applicants' invention comprises a technique for minimizing pulsation artifacts by adjusting the encode process of the frame as soon as the frame is identified to comprise a still frame. Applicants respectfully submit that a careful reading of Reininger et al. fails to uncover any teaching, suggestion or implication to one skilled in the art of such a technique.

The Office Action recognizes that Reininger et al. does not appear to disclose the limitation of "minimize after decoding thereof, visually perceptible pulsation artifacts between still frames of a sequence of still frames". However, the teachings of Astle are cited to address this deficiency. Specifically, the Office Action alleges that the "block edge artifacts" discussed in Astle equate to the "pulsation artifacts" defined by applicants in the independent claims presented herewith. The Examiner's use of "pulsation artifact" as a substitution for "block edge artifacts" in the Astle discussion is respectfully traversed.

As understood by one skilled in the art, the phrase "block edge artifacts", and the discussion of Astle, describe artifacts caused within a picture itself from difficulty in encoding pixels of different frequencies, for example, when transitioning from a black edge to a white space. In contrast to this artifact, applicants' "pulsation artifacts" are temporal artifacts caused by difference in compression ratios between two sequential pictures.

The phrase "pulsation artifacts" is understood in the art and defined in the present application to mean visually perceptible pulsations which may occur in a sequence of still content frames which have been displayed after undergoing encoding and decoding of the identical frames.

Additionally, a careful reading of Astle fails to uncover any teaching, suggestion or implication of a process for adapting encoding of a frame when the frame is a "still frame" as discussed above and defined in the independent claims presented herewith. Thus, applicants respectfully traverse the characterization in the Office Action that "... Astle discloses the illumination of the block edge artifacts (i.e., pulsation artifacts) after the decoding of a series of encoded still frames or images (Col. 6, lines 25-47)." There is no discussion or suggestion in the Astle patent that the individual frames that are being decoded are still frames having still content similar to the present application. The Office Action's characterization of the teachings of Astle as relating to decoding of a series of encoded still frames is without basis in the Astle patent, and therefore believed erroneous. There is no discussion in Astle of a still frame, nor is there discussion in Astle of a series of encoded still frames. Further, Astle is not even discussing an encoding process, but rather is addressing the decoding process. The Astle patent relates to a problem which is different from that of the present invention. In Astle, the problem of "block edge artifacts" is addressed by smoothing out a picture using blending techniques during the decoding process. For all the above reasons, the problem addressed by Astle, and the teachings thereof, are vastly different from applicants' recited invention.

Thus, applicants respectfully request reconsideration and withdrawal of the obviousness rejection to independent claims 1, 19, 23, 34 & 37 based upon the teachings of Reininger et al. in combination with Astle. The dependent claims are believed allowable for the same reasons as the independent claims from which they depend, as well as for their own additional characterizations.

No new matter is added to the application by any amendment presented herewith.

The claims are believed to be in condition for allowance and such action is respectfully requested.

Should the Examiner wish to discuss this case with applicants' attorney, please contact applicants' attorney at the below-listed number.

Respectfully submitted,

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Dated: October 22, 2002

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Version With Markings to Show Changes Made

In the Claims:

Claims 1, 19, 23, 34 & 37 have been amended as set forth below:

1. (Fifth Amendment) A method for encoding a sequence of video frames comprising for each frame of the sequence of video frames:

(a) encoding said frame employing at least one controllable parameter; and

(b) adapting said encoding (a) of said frame when said frame is a still frame, said still frame being determined prior to said encoding (a) and comprising a frame with certain content identical and unvarying to certain content of a preceding frame, said adapting including adjusting said at least one controllable parameter employed in encoding said still frame to disable motion estimation and limit motion compensation to minimize after decoding thereof, visually perceptible pulsation artifacts between still frames of a sequence of still frames within said sequence of video frames, wherein said still frame comprises one still frame of said sequence of still frames.

19. (Fifth Amendment) A method for encoding a frame of a sequence of video frames, said frame having a plurality of macroblocks, said method comprising for each of at least some macroblocks of said plurality of macroblocks:

(a) encoding said macroblock employing at least one controllable parameter; and

(b) adapting said encoding of said macroblock when said macroblock is a still macroblock, said still macroblock being determined prior to said encoding (a) and comprising a macroblock with certain content identical and unvarying to certain content of a corresponding macroblock in a preceding frame,

said adapting including adjusting said at least one controllable parameter employed in encoding said still macroblock to disable motion estimation and limit motion compensation to minimize after decoding thereof, visually perceptible pulsation artifacts between corresponding still macroblocks of adjacent frames in said sequence of video frames.

23. (Fifth Amendment) A system for encoding a sequence of video frames comprising:

a pre-encode processing unit, said pre-encode processing unit comprising:

a statistics measurement unit for use in determining prior to encoding whether a current frame of the sequence of frames comprises a still frame, said still frame comprising a frame with certain content identical and unvarying to certain content of a preceding frame;

a control unit for modifying at least one controllable parameter employed in encoding said still frame to disable motion estimation and limit motion compensation to minimize after decoding thereof, visually perceptible pulsation artifacts between still frames of a sequence of still frames when said statistics measurement unit determines said current frame to comprise said still frame; and

an encoding engine for encoding said current frame of the sequence of video frames using the at least one controllable encode parameter set by said pre-encode processing unit.

34. (Fifth Amendment) A system for encoding a macroblock of a plurality of macroblocks of a frame in a sequence of video frames, said system comprising:

an encoding engine for encoding said macroblock of said frame using at least one controllable encode parameter; and

means for adapting said encoding of said macroblock when said macroblock is a still macroblock, said still macroblock being determined prior to receipt of the still macroblock at the encoding engine, and comprising a macroblock with certain content identical and unvarying to certain content of a corresponding macroblock in a preceding frame, said adapting including means for adjusting said at least one controllable parameter employed in encoding said still macroblock to disable motion estimation and limit motion compensation to minimize after decoding thereof, visually perceptible pulsation artifacts between corresponding still macroblocks of adjacent frames in said sequence of video frames.

37. (Fifth Amendment) A computer program product comprising a computer usable medium having computer readable program code means therein for use in encoding a sequence of video frames, said computer readable program code means in said computer program product comprising for each frame of the sequence of video frames:

computer readable program code means for causing a computer to affect determining, prior to encoding, whether said frame comprises a still frame, said still frame comprising a frame with certain content identical and unvarying to certain content of a preceding frame;

computer readable program code means for causing a computer to affect encoding said frame employing at least one controllable encode parameter; and

computer readable program code means for causing a computer to affect adapting said encoding of said frame when said determining determines said frame to be said still frame, said adapting including adjusting said at least one controllable parameter employed in encoding said still frame to disable motion estimation and limit motion compensation to minimize after decoding thereof, visually perceptible pulsation artifacts between still frames of a sequence of still frames within said sequence of video frames, wherein said still frame comprises one still frame of said sequence of still frames.